U.S. NAVAL SUBMARINE BASE,
NEW LONDON SUBMARINE ESCAPE TRAINING TANK
(Building 70)
Albacore and Darter Roads
Groton
New London County
Connecticut

HAER No. CT-37-A

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
Mid-Atlantic Regional Office
National Park Service
U.S. Department of the Interior
Philadelphia, Pennsylvania 19106

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Submarine Escape Training Tank
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Location:	Albacore and Darter Roads, U.S. Naval Submarine Base, New London Groton, New London County, Connecticut UTM: 18.743050.4586510 Quad: Uncasville, Connecticut
Date of Construction:	1929-1930. Alterations and additions in 1932, 1937, ca. 1940, ca. 1944, 1950, 1958, 1960, 1961, 1978
Present Owner:	Naval Submarine Base, New London; Groton, Connecticut
Present Use:	Vacant (decommissioned in 1982); to be demolished
Significance:	The Submarine Escape Training Tank was constructed for the purpose of training U.S. Navy submariners in the use of re-breathing apparatus and in emergency procedures for escaping from disabled submarines. The 119-foot, 6-inch steel standpipe contained locks or compartments, modeled on those in actual submarines, at the 18, 50 and 110-foot levels, through which students from the U.S. Naval Submarine School entered the tank and ascended under close supervision from instructors. Successful completion of the escape training course was a prerequisite for all prospective submariners. The experience provided not only practical training for emergency situations, but, through accomplishment of a rite of passage, fostered a sense of individual pride and confidence, which the Navy considered an important quality in its submarine personnel. In addition, the tank, for much of its history under jurisdiction of the Medical Research Laboratory, was employed in numerous research programs that examined biomedical and behavioral problems associated with submarine and diving environments, or were designed to test and improve escape techniques and equipment. Six of the eight small buildings that envelop the base of the tank were constructed, at various times, to support these training and research activities. The remaining two buildings contained machinery and equipment for operation of electrical, heating, compressed air and hydraulic systems. The Submarine Escape Training Tank is one of two essentially identical structures designed by the U.S. Navy's Bureau of Yards and Docks. The second tank was erected at Naval Submarine Base, Pearl Harbor, Hawaii, to serve personnel of the Navy's Pacific fleet.

Project Information: The Submarine Escape Training Tank was documented in October 1987 by Louis Berger & Associates, Inc., of East Orange, New Jersey, for the Department of the Navy, Northern Division, Naval Facilities Engineering Command. The work was carried out pursuant to a Memorandum of Agreement between the Department of the Navy, the Connecticut State Historic Preservation Office, and the Advisory Council on Historic Preservation. The project team consisted of John A. Hotopp, Ph.D., director; Martha H. Bowers, architectural historian; Rob Tucher, photographer; Ingrid Wuebber, assistant historian; and John R. Bowie, AIA, consulting architect.

I. DESCRIPTION:

The subject of this recordation project is a facility designed and built in 1929-30 to provide training in methods by which individuals might escape from disabled submarines. The Submarine Escape Training Tank is located on the Naval Submarine Base, New London, where the Navy's Submarine School has produced the great majority of American submariners since its establishment in 1917. The escape training tank at New London is one of two such facilities built by the Navy. The other, erected in 1932, is located at the Naval Submarine Base, Pearl Harbor, Hawaii.

The Naval Submarine Base is situated on the east bank of the Thames River in Groton, Connecticut. It occupies over 500 acres between the river and Connecticut State Route 12. The base is divided into "upper" and "lower" sections, the line of demarcation being Shark Avenue and the Providence & Worcester Railroad right of way, which run parallel to one another north to south through the facility. The larger Upper Base contains administrative buildings, housing, and a wide variety of personnel support facilities. The escape training tank is located on the Lower Base, the primary mission of which is provision of support for forces of the Atlantic Fleet afloat. Thus a major activity is the servicing and repair of submarines and support vessels, which are accommodated at 13 piers and a drydock in the Thames River. Vehicular access to the piers is via Albacore and the northern portion of Amberjack roads, which run along the river bank. Buildings within the Lower Base are tightly arranged, with the very small amount of open space between them typically used for parking or service vehicles. The Escape Training Tank itself is located almost directly opposite Pier 12, at the northeast corner of Albacore and Darter roads.

The escape training facility consists of the tank itself plus an assemblage of small buildings which, connected to one another, completely envelop the base of the tank. The tank foundation is an octagonal reinforced concrete spread footing set on oak and pine pilings. The footing measures 36 feet across and is approximately 5 feet thick. Twelve steel hold-down rods, of 2 1/8-inch diameter, are arranged at regular intervals around the base of the tank to anchor the structure to the foundation. The bolts at the bottom ends of the rods are attached with welded connections to copper-coated ground rods which extend from the base of the foundation into the earth.

The training tank itself is essentially a hollow cylinder, 18 feet in diameter and 119'6" high, with a capacity of about 250,000 gallons. It is constructed of riveted steel plates which vary in thickness from 9/16" at the base (where the water pressure is greatest) to 5/16" at the top. The joints also exhibit systematic variation from base to top (butt with reinforcing plates; triple-rivetted lap; double-riveted lap; and single-riveted lap) and all the horizontal joints, except those at the base and top, are further strengthened with 6-inch channel stiffening rings. The tank shell is pierced by small circular "bullseyes", which are small thickly-glazed portholes. These construction features are obscured beneath insulation and corrugated metal exterior cladding.

Around the top of the tank is a steel-framed octagonal loft or cupola, approximately 14 feet high and 25 feet across, which is carried on steel brackets riveted to the upper edge of the tank. Both the tank and the cupola are clad on the exterior with corrugated sheet metal. Extending around the tank from the base to the cupola is an open spiral stair with pipe railings and stringers of riveted steel channels supported on steel brackets.

At the 18 and 50 foot levels are enclosed, polygonal landings or platforms (levels are measured in terms of depth below the water surface). These are supported on a steel frame attached to the south side of the tank, extending from the base to the 18 foot level, which originally carried high pressure air and water pipes. Each of these platforms, as well as the cupola, can be entered from the spiral stair. In addition, each is connected by means of a short enclosed passageway to an elevator shaft set approximately 18 feet west of the tank. Like the tank itself, the steel-framed elevator shaft is set on an octagonal reinforced concrete spread footing, set on wooden pilings, and is clad with corrugated metal.

Enclosed within the 18 and 50 foot platforms are air, or escape, locks (chambers capable of being pressurized), constructed of three sections of curved 3/8-inch steel plate and riveted to the exterior of the tank. Each lock is fitted with two watertight doors (which replicate those used in submarines), one of which provides access to the lock from the platform. The other provides access to the interior of the tank, opening inward only when the pressure in the lock is equal to that in the tank at that level.

Within the base of the tank, at the 110 foot level, is a cylindrical steel compartment, 12 feet in diameter, which is situated horizontally about 5 feet above the tank floor. This watertight compartment, called the "submarine section", is entered from the exterior through a watertight door. Projecting from the upper surface of the submarine section are an escape trunk (with exit from the side) and an escape hatch (with exit from the top), modeled after those on British and American submarines, respectively. These features provide access to the interior of the tank at the 110 foot level.

A fourth means of entry into the tank occurs at the 100 foot level, through a watertight door on the north side of the tank (opposite and above the door into the submarine section). No air lock is provided at the 100 foot level, so entry through this door is limited to periods when the tank is empty.

In addition to the 18 and 50 foot locks, which are enclosed within their respective platforms and accessible from the outside, there are three steel chambers, called blisters, which also project from the sides of the tank but are accessible only from within the tank. Two of these, called the 25 foot and 40 foot blisters, are situated approximately opposite one another at the 25 foot level. The third is located at the 75 foot level. The blisters do not have watertight doors; access to and from a blister is through a rectangular opening approximately 3 feet by 4 feet, above which is a 1-foot by 3-foot view opening fitted with 3/8-inch Plexiglass.

In addition to these "instructors" blisters, there are four small blisters containing floodlights which illuminate the interior of the tank. These blisters are 2 feet in diameter and project about 1-1/2 feet from the side of the tank. One floodlight blister is located below the 75 foot blister, another below the 50-foot lock, a third between the 50-foot lock and 40-foot blister, and the fourth just above and to the right of the 25 foot blister.

The 18 and 50 foot platforms and their associated passageways to the elevator are simply a means of access to the air locks and as such are finished in minimal, utilitarian fashion with concrete floors, corrugated metal ceilings, metal wall panels, exposed steel window framing and "awning" type metal sash. The interior of the cupola, however, is finished with vertical composition wall boarding, blue all-weather carpet, and three-unit horizontal sash, the upper two sash of the moveable "awning" type, the lower fixed. Around the edge of the tank are aluminum railings positioned to provide hand-holds for each of 18 ladders, regularly spaced around the inner surface of the tank and extending to a depth of approximately 10 feet. Above the tank is a 1-1/2 ton electric crane hoist, installed in 1970, from which an open-platform diving bell (no longer present) was suspended for use in emergencies during escape training. On the north side of the cupola is a bulkhead in the floor (from which the cupola is entered from the spiral stair) and a urinal semi- enclosed within walls approximately 4 feet high. In the passageway to the elevator, which is wider than those at the 18 and 50 foot levels, is a two-lock hyperbaric or recompression chamber built in 1956 by the Dixie Manufacturing Company, Baltimore, and installed at this location the same year.

The Submarine Escape Training Tank was built in 1929-30 from designs generated by the Navy Department's Bureau of Yards and Docks.[1] The steel tank and stair were fabricated and erected by the Petroleum Iron Works Company of Ohio, located in Sharon, Pennsylvania.[2] According to the original drawings, the pilings and foundation were installed by the Navy. The Naval Yard, Portsmouth, New Hampshire, prepared plans for the watertight doors, doorways and bullseyes, all of which elements were provided by the Navy for installation.[3]

The elevator was erected in 1932. The designs for the elevator, also generated by the Bureau of Yards and Docks, were intended for use both at New London and the identical tank erected at Pearl Harbor in 1932.[4] The shaft was constructed by the H.H. Robertson Co, of Pittsburgh, while the elevator was provided by the Blake, Palm Elevator Corp. of Washington, D.C.[5] During construction of the elevator and walkways, the 18 and 50 foot platforms, as well as the entire spiral stair, were enclosed, so that the facility could be used in relative comfort year-round (at Pearl Harbor, only the passage to the cupola was enclosed).

No other major changes were made to the tank until the 1950's. During that decade, however, the cupola windows were replaced (1953), a new elevator mechanism installed (1955) and the recompression chamber installed in the passageway between the elevator and cupola.[6] In 1959, the three instructors' blisters and the floodlight blisters were added. Designed by the Navy's Bureau of Yards and Docks, they were manufactured by Fletcher-Thompson, Inc. of Bridgeport, CT.[7] In 1961 the structure was given a major overhaul, the cupola was insulated and its windows replaced, and all the passageways were widened and refinished (the structures enclosing the spiral stair are believed to have been removed at this time).[8] Seven years later, in 1968, a fire started in the base diving locker and spread up the elevator shaft to the cupola.[9] The damage was repaired, and the tank returned to service. In 1972, the Navy undertook remedial foundation work involving the cantilevering of reinforced concrete grade beams beneath the spread footing of the tank. The tank was given a thorough overhaul in 1976-78, including the insulating of the exterior.[10] The tank was decommissioned in 1982 due to structural deterioration, the repair of which an engineering study determined to be insufficiently cost-effective to justify.

The assemblage of small buildings at the base of the escape training tank is the product of at least eight construction episodes, occurring between 1930 and 1960, plus numerous alterations and remodeling efforts which appear to have been continued almost to the decommissioning of the tank in 1982. After the tank was decommissioned, the buildings continued to serve office and classroom functions until the entire escape training facility was closed in 1987.

<u>Equipment House, 1930</u>. The equipment house is the oldest unit in the assemblage, having been erected at the same time as the training tank.[11] The one story, one-room structure measures approximately 23 feet by 34 feet, and has reinforced concrete footings, floor beams and floor, and brick exterior walls. The shallow gable roof is carried on exposed wooden king-post trusses, the east halves of which are subdivided to support piping. The north end of the equipment house is set on a portion of the tank's octagonal spread footing, and the north wall is built to encompass that portion of the tank containing the watertight door to the submarine chamber. A platform, inserted approximately 8 feet above the floor in the steel frame which rises up the south side of the tank, provides access to the submarine chamber door.

The equipment house originally contained three windows on the east side, and a door and two windows on the west, as well as a wide double-leaf door in the south end. As a result of subsequent construction episodes, the northernmost window on the east side was reworked as a doorway and the remaining two windows bricked up, as was one window on the west side. In 1957 the entire south wall of the building was removed, the room lengthened by about 5 feet, and a concrete platform erected along the east wall to carry a water filter and two pumps.[12] A wooden overhead roll door in the reconstructed south wall now provides the only access to this room, which is illuminated by suspended fluorescent lights, from the outside.

The principal function of the equipment room has always been to house the recompression chamber in which Submarine School students received their 50-pound pressure tests. The existing triple-lock steel chamber, the installation of which occasioned the lengthening of the structure toward the south in 1957, was supplied by the Dixie Manufacturing Co. of Baltimore.

Examining Room, 1932. This structure was built during erection of the elevator.[13] It consists of one room, approximately 24 feet square, with a nine-foot-square projection from the north wall which functions as a lobby for the elevator and contains the motor-generator which provides the DC current necessary for operation. The examining room has brick exterior walls, supported on concrete foundations, and a linoleum-covered concrete floor. In the south wall is an exterior entrance, a tall 6/6 wooden double hung sash window, and a smaller window apparently inserted subsequent to original construction to illuminate the toilet and shower which are contained within the partitioned spaces in the southwest corner. Originally, the entire west portion of the room was set off as a dressing room and toilet, the remaining space used as a medical office. As a result of subsequent construction, the partitioned spaces on the west were reconfigured to provide room for a "corridor" to the Medical Research Laboratory annex erected on the east side of the Examining Room in 1950 (see below).

Addition to Equipment Room (Pump Room), 1937. This one-story, one-room unit is constructed off the east side of the equipment room.[14] The structure measures 24 feet by 34 feet, and has brick walls set on a foundation of reinforced concrete footings on wooden pilings. Its broad gable roof, the ridge of which is oriented perpendicular to that of the equipment room, is supported on exposed wooden trusses.

This room contains most of the mechanical equipment used to supply water and compressed air for operation of the training tank. Water is continuously recycled, both to maintain cleanliness and to maintain a constant temperature of 92 degrees within the tank. Water is drawn off from near the top of the tank through a pipe leading down to the 14-foot-diameter overflow storage, or "spill" tank, a riveted steel structure located in the northwest corner of the pump room. From this tank, water enters a steam exchanger, where it is heated to 92 degrees. A circulation pump then passes the heated water through a water filter located along the west wall of the adjacent equipment room. The water (some first diverted to be mixed with chlorine) is then pumped into the base of the tank.

Compressed air is provided by two 5-stage Worthington compressors located in the pump room south of the spill tank. High pressure (3,000 psi) air is then stored in fourteen 11 1/2-foot steel canisters located in the High Pressure Air Flask Room, a windowless, one-room free-standing concrete structure built adjacent to the south wall of the pump room in 1976. When the tank is in operation, this air is drawn off, through a set of cloth filters to a reducer, where the pressure is reduced to 250 psi. After passing through a line filter to remove moisture, the air enters distribution manifolds, located along the west wall of the pump room, which convey air as needed to the locks, blisters, submarine chamber and recompression chambers.

<u>Shower and Dressing Room, ca. 1940</u>. This unit was built off the north wall of the pump room sometime between 1937 and 1943.[15] It was originally constructed with two stories, of brick on concrete foundations, to which a third was added after 1968. The first story, measuring approximately 17' x 27', abuts the east side of the training tank in order to permit access from the equipment room. The west half of the first floor contains a shower and toilet area, plus an enclosed stair along the south wall. The east half contains a dressing room with linoleum floor, painted brick walls and wall-mounted radiators. The wooden windows have fixed upper sash and horizontally-hinged awning-type lower sash. The second floor (17' x 22'), originally partitioned into two rooms, is now a single space used as an instructors' lounge, with plywood wall panelling, dropped acoustical tile ceiling, and sink and counter unit along the north wall. The third floor (also 17' x 22') is partitioned into three small rooms.

<u>Underwater Welding Room (SCUBA Room), ca. 1944</u>. This structure was built to the northwest of the training tank and appears to have originally been a separate, freestanding unit.[16] The two-story structure has approximate dimensions of 17 feet by 25 feet and was originally fitted with a hipped roof which was replaced with a flat roof following the 1968 fire. The brick exterior walls are supported on concrete foundations and contain very tall wood 6/6 double hung sash with concrete lintels and sills. The building was constructed to contain a water tank, 8 feet in diameter and approximately 12 feet deep, apparently for instruction in underwater welding techniques. The tank is no longer present, nor is the flight of stairs along the north wall that once provided access to the second floor and the top of the tank. However, the octagonal framing of the exposed second floor joists, and a thin ridge in the linoleum covering the lower floor, indicate the former presence of the tank. The first floor room, subsequently called the Diving Locker and SCUBA room, also

has painted brick walls and a counter/sink assembly in the northeast corner. The upper room, illuminated with 6/6 wooden double-hung sash windows slightly smaller than those on the floor below, has a dropped acoustical tile ceiling and was most recently used as a classroom.

Medical Research Laboratory Building ("Annex", Storage Room), 1949-50. This one story, one-room unit is located off the west wall of the examining room. The reinforced concrete floor is supported on reinforced concrete floor beams which in turn rest on the concrete caps of 30-foot oak pilings. The massiveness of this work was designed to support a recompression chamber (no longer present) which was inserted into the room through an entry fitted with a wooden overhead roll door in the south wall.[17] The exterior walls are brick; 6/6 wooden double hung sash have concrete sills and steel lintels. The roof, the gable end of which faces west, is carried on wooden trusses above a high suspended ceiling.

Office and Classroom Building, 1958. This construction episode created a permanent link between the Underwater Welding Building and the rest of the assemblage at the base of the training tank. Prior to this, there had been a wood-framed enclosure from the south of the Underwater Welding Building to the area around the base of the elevator and the Medical Research Laboratory Building; its west wall followed the line of the elevator's foundation.[18] The 1958 construction involved erection of a concrete block wall between the south wall of the Underwater Welding Building and the north wall of the elevator lobby, plus a section approximately 18 feet by 25 feet, of concrete block covered with facebrick, off the north wall of the Medical Research Lab. This section is built on concrete perimeter walls; the area beneath the concrete slab floor is filled with sand and cinder over fill. The first floor of this section contains a classroom, subsequently converted to an office, which is set off by wood floor-to-ceiling partitions with wire glazing from a corridor which extends north-south from the Medical Research Lab to the Underwater Welding Building. Off the east side of this corridor, behind the elevator, is a flight of stairs to the second floor. On the second floor is a second classroom, with linoleum floor, dropped acoustical tile ceiling, and two- section wooden windows, the lower sections of which are hinged at the bottom. The original gable roof of this classroom structure was replaced with the existing flat roof after the 1968 fire.

Work/Chamber Room (Repair Shop), 1959-60. Erection of this section marked the last major construction episode in the assemblage of buildings and rooms around the escape training tank.[19] The flat-roofed, two-level structure rests partly on the north edge of the tank foundation and partly on reinforced concrete grade beams set on concrete-capped timber pilings. It is framed with wooden studs and clad on the exterior with corrugated metal siding. Windows are four-light metal awning- type units. The first level has a linoleum-covered concrete floor and the east side is partitioned off by a floor-to-ceiling steel mesh grille behind which is a repair shop. The second level is finished with all-weather carpeting, plywood paneling and suspended acoustical tile ceiling. It is accessed from a flight of stairs along the west side of the tank which descend to the "mezzanine" containing the platform at the level of the submarine chamber.

This structure was originally built to house a recompression chamber mounted opposite the hatch at the 100-foot level on the north side of the training tank. A large steel frame, some 17 feet high, was erected on the first floor, creating a platform on which the chamber could be placed at the appropriate level (the second floor was apparently framed around this platform). The north wall of the building was designed so as to be removable for installation or removal of the chamber, and thus the northern portions of the east and west walls were fitted with diagonals between studs to ensure their stability.

Both the chamber and its platform have been removed, and the first level remodeled to contain a repair shop. Conversion of the second level to classroom use also included construction of the existing stair to the mezzanine, plus the partitions which now enclose most of the west and north sides of the tank at this level.

II. <u>HISTORY AND OPERATION OF THE SUBMARINE ESCAPE TRAINING TANK</u>

A. Historical Background

Naval Submarine Base New London was established in 1916 on a 112-acre tract located on the east bank of the Thames River which the State of Connecticut had donated, for Navy purposes, to the U.S. Government in 1867. Designated a Navy Yard in 1872, the tract at that time contained two buildings and a T-shaped pier, intended primarily for "laying up ships in ordinary," i.e., mothballing unused vessels. By 1881 the facility had taken on the added mission of providing coal to small craft of the Navy's Atlantic Fleet, but its physical plant was only slightly enlarged to accommodate the new activity. A fire in the coal storage area terminated coaling at the base, and by the first decade of the 20th century the facility was essentially moribund.[20]

In 1900 the Navy commissioned its first submarine, the USS Holland (SS-1). In March of 1912, the Secretary of the Navy established the Atlantic Submarine Flotilla, with Lt. C.W. Nimitz as commanding officer. In May of the same year, the Navy, apparently finding no real use for the New London base, proposed to Congress that it be disposed of. However, legislators heeded the protests of their colleague, Rep. Edwin Higgins of Norwich, Connecticut, and refused to approve the Navy's request.[21]

Three years later, five submarines (D-1,D-2, D-3, G-1 and G-2) escorted by the monitor Ozark as tender, arrived at the New London Naval Base. In June 1916, Submarine Force U.S. Atlantic Fleet was established, and the New London facility designated a Submarine Base, among its missions that of training officers for submarine duty. The Submarine School was formally established on 1 January 1917, with Lt. F.X. Gygax as Officer in Charge. Over 10,000 officers and men were trained for submarines at this school during World War I.[22]

After the war, activities at the Submarine Base were reduced to reflect the reduced needs of the peacetime Navy. The Submarine School, however, continued its programs of training new submarine personnel, and its curriculum was expanded in the 1920's to include developments in submarine rescue and escape, the most obvious manifestation of which was erection of the Escape Training Tank in 1929-30.[23]

The enormous demands of World War II brought major expansion of the Submarine Base and its mission. Between 1935 and 1945, the Base increased its land area from the original 112 acres to 497 acres, and its building stock from 86 to 270 structures. By 1945, some 2,000 officers and 22,000 enlisted men had been processed through the base's two major training facilities, the Submarine School and the Precommissioning Group, which provided more specialized or advanced training and supervised requalification of returning submarine personnel. It was during this period also that the Medical Research Section was established, in effect formalizing the investigations of problems related to submarine and diving environments which had already been topics of study for some years.[24]

After World War II, the Submarine Base continued to perform, with increasing refinements, its historic mission as one of the Navy's major training facilities. The School was upgraded from a departmental activity to a separate command in 1968, and by the 1970's was teaching 50,000 students each year and had become the largest fleet school in the Navy. Offering over 300 courses and with facilities in buildings located throughout the Submarine Base, the Submarine School continues to "provide the basic knowledge and technical skills upon which operational submarine commands in the Atlantic and Pacific submarine forces can build competency and proficiency in operating and maintaining submarines and all their systems."[25]

B. Evolution of Techniques in Individual Submarine Escape

The Submarine Escape Training Tank was built to train submariners in the use of individual escape apparatus and in techniques for escaping from disabled submarines. The sinking of three submarines in the peacetime of the 1920's (the S-5 in 1920, the S-51 in 1925 and the S-4 in 1927), provided the impetus for studies in procedures and equipment by which crews might have reasonable chance of escape from disabled boats. An important early result of the Navy's concern was development of the McCann Rescue Chamber, a cable-controlled lock, carried on rescue vessels, designed for group escape. At the same time, the Navy initiated investigations to discover safe methods of individual escape. The latter project was first directed by Lt. C.B. Momsen, whose "lung" was first successfully tested in 1929. The lung was basically a closed-circuit SCUBA with a reservoir bag for air, a CO_2 absorbent-containing canister, and a flutter valve to release expanding gas on ascent. Training using the Momsen Lung (also known as the Submarine Escape Appliance or SEA), was the rule at New London until 1946, when instructors and selected students began to use the technique of free escape or free ascent. This technique was based on the principle that with his lungs fully inflated, a man would be buoyant at any depth. The object of training using this technique was thus to maintain sufficient air in the lungs at a given depth to provide positive buoyancy, but at the same time not let the pressure of the alveolar air (expanding in the course of ascent) become great enough to cause air embolism.[26]

The technique of buoyant-assisted free ascent, which emerged out of studies conducted by the British beginning in 1946 on instances of successful escape from disabled submarines, was formally adopted by the Navy in 1956. Commonly known as "buoyant ascent," this method was considered an improvement over free ascent because it provided buoyancy to individuals who lacked natural buoyancy, and because it prevented a man from becoming disoriented in black or murky water. However, the inflated vest which provided the buoyancy also increased the rate of ascent substantially (over 400 feet per minute); while this meant an individual surfaced more quickly, it also meant that pressure from expanding air inside the lungs would increase much faster.[27] The technique was substantially improved by Lt. Harris E. Steinke, Officer-in-Charge of the Escape Training Tank, who developed a vest with an attached hood. Air vented from the vest passed through the hood to provide ventilation and keep the hood expanded during ascent. With the hood keeping water away from an individual's face, he was able to exhale in a more normal (and thus efficient) manner. Developed in 1960 and successfully tested in open water from the USS Ballao off Key West in 1961, the "Steinke hood" was made generally available to initial Submarine School qualifiers in July 1965, and since then has remained the Navy's primary apparatus for individual escape.[28]

C. Procedures in the Submarine Escape Training Course

In the crudest terms, and regardless of technique employed, individual submarine escape training essentially consisted of introducing a student into the tank through one of the air locks, from which he ascended to the surface. The following discussion of the training experience, as it was performed at the time the tank was decommissioned in 1982, is based upon descriptions provided on 28 and 29 October, 1987 by EMCM/DV B.C.Tuck and BMC/DV M.R. Noyes, instructors from the Submarine Escape Training Department at Naval Submarine Base, New London, and upon Submarine Escape Training Department Instruction 5400.1B, dated 19 August 1977.

Escape training was a two-day course, consisting of classroom instruction and a pressure test, followed approximately one week later by experience in the tank itself. Each "class" consisted of 45-50 students who, after a 45 minute lecture, were placed in groups of 10 or 12 into the large triple-lock recompression chamber in the equipment room. Here, they were subjected to a pressure of 50 lb. per square inch (equivalent to a depth of 112 feet below the surface), all the while observed closely by instructors within and outside the chamber. Once released from the chamber, the students were observed for another 5 minutes to ensure identification of any difficulties a student might have had during or after the experience.

On the second day, students received an additional classroom lecture on escape training and use of the Steinke hood. They then showered, donned bathing trunks, and were taken to the cupola of the tank for ladder training. This exercise required a student to descend one of the ladders attached to the inner surface of the tank to approximately the 10 foot level, then ascend, free of the ladder, while exhaling strongly and steadily in the "blow and go" method.

Once the class members had completed ladder training, students were taken down, in the elevator, to the 50 foot level. One group of 10 or 12, plus an instructor, entered the lock chamber. The exterior watertight door was secured and the chamber flooded with water to a level just above the top of the door between tank and chamber. The pressure in the chamber was equalized through introduction of compressed air; once achieved, the interior door was swung inward. The first student, who with the others had donned a Steinke hood, had his vest inflated by the instructor. Upon an order from the supervisor "topside" in the cupola, the student took a deep breath and "stepped" into the tank, into the waiting hands of two diving instructors called Hookas, so termed for the air hoses attached to their scuba regulators. Low Hooka, positioned directly in front of the door, assisted the student into the tank, held him while he assumed proper position (legs straight, feet together, arms straight over the head) and started his "ho-ho-hos" (by which means the student would continuously exhale during his ascent). High Hooka, straddling the tied-back door, also checked the student for correct position and ho-ho-hos. If all seemed well, the student was maneuvered by the Hookas away from the door and toward a tautly-strung cable (called a "wire"), which would serve as a guide to the surface. Rising at a rate of 425 feet per minute (due the buoyancy provided by the vest), the student was handed off to the "40 foot man", a diver stationed above the Hookas at the 40 foot level. From this man, the student was passed to a diver on station at 25 feet, who escorted the student to the surface. At the surface, the student ascended one of the ladders, said, loudly and clearly to a waiting corpsman "I feel fine!". He then assumed parade rest (standing erect with hands clasped behind him) for a period of 5 minutes, during which time he was checked for signs of potential air embolism (often indicated by the dilation of one pupil) or other signs of discomfort or distress.

As suggested by the "handing-off" procedure, a student undergoing ascent was never alone from the time he entered the 50 foot lock to the time his condition, following ascent, was assured topside. Further, a variety of procedures and personnel were employed so that a student's ascent could be terminated at once should he experience any difficulties. From its first days in service, the tank was equipped with a roving diving bell, stationed approximately midway in the ascent, to which student with problems could be immediately brought to the surface for observation or treatment. The blisters also provided a further measure of safety, serving as internal platforms to which a student could be brought, his hood removed and his condition assessed, prior to his being transferred to the roving bell and taken to the surface. Two instructors were assigned to each blister, one to form part of the "chain" of instructors monitoring the student during ascent, the other remaining in his blister to watch his partner "on station" and to assist in any emergency.

Construction of the blisters in the late 1950's was the most visible manifestation of the changes and improvements in both escape techniques and in methods of instruction employed to move students through the procedure. For example, in the first years of tank training, the instructors did not enter the water (except to operate the roving bell), instead observing trainees from the exterior stair through the bullseyes in the sides of the tank. Toward the end of the 1930's, however, instructors took advantage of evolving skin-diving techniques to maintain close underwater supervision, a practice maintained through the subsequent history of the facility.[29] Trainee safety was also a factor in the decision to discontinue regular ascents from the submarine level in the 1960's due to the large number of students and shortage of instructors (although instructors were commonly trained from this level until the early 1970's).[30] The use of the roving bell also changed over time, having been used at least into the 1940's as a platform (at about 12 feet) from which trainees made initial ascents with the Momsen lung.[31] This practice was subsequently discontinued, and the bell was utilized primarily as a rescue device. Even the distinctive "ho-ho-ho" procedure evolved from an earlier technique which required individuals to say "ok-ok-ok." The latter was discontinued in the spring of 1964 when it was determined that the closure of the glottis in order to pronounce the "k" sound was inhibiting the reduction of pressure in the lungs.[32]

D. Role of the Escape Training Tank in Selection and Requalification of Submariners

The two-day escape training course served not only as a vehicle for instruction in individual escape methods, but also as an integral element in the selection of men for Submarine School. All candidates for Submarine School (both enlisted men and officers) were required to pass rigorous physical and psychological tests administered by the Medical Research staff. Although a certain latitude of performance was permitted in some tests, failure or problems in others resulted in a Submarine School applicant's automatic disqualification from further instruction and reassignment.[33]

Among the latter tests was the escape training course. Certainly, the ability to withstand, and to comfortably perform in, a pressurized environment was a fundamental requirement of any submariner: thus the 50-lb. pressure test administered on the first day of the course provided a simple but decisive method by which to identify non-qualifying individuals. The tank training portion of the course then presented two more tests: only those individuals performing properly in ladder training were permitted to make an ascent from the air locks, and only those who completed the requisite number of ascents (usually two) were permitted to continue their submarine training.[34] The peculiar environment aboard submarines was a major factor in the psychological testing of would-be submariners. In this regard, the escape training course served a valuable purpose, as "border-line cases revealed by the psychiatric exams frequently evidenc[ed] themselves when undergoing tests in the...tank."[35]

The point at which Submarine School students took the escape training course appears to have varied. During World War II, the course was administered as part of the medical screening which occurred prior to any instruction in submarines. By the late 1970's, those taking the course had already been admitted to Submarine School, but the tests were performed within the first few weeks of classes.[36]

In addition to providing training for initial qualifiers, the tank was employed by other submariners as part of the requalification process. Requalification, undertaken at stipulated intervals, was intended to retrain personnel in procedures with which they might have become unfamiliar, and to introduce them to new techniques or equipment. In general, personnel of the Atlantic Fleet requalified in escape techniques at the New London tank, while the tank at Pearl Harbor performed a similar function for men of the Pacific Fleet.[37]

The escape training facility was also used for diver training. The Divers School, for much of its history under the jurisdiction of the Medical Research staff, trained men to be 2nd Class divers, as well as offering instruction in SCUBA technique. During World War II, graduates of the Divers School could also take courses in underwater burning and welding, using a tank installed in a small building adjacent to the escape training tank itself. In 1968, with designation of the Submarine School as a separate command, SCUBA training was incorporated into the Submarine Escape Training Department, one of the dozen training and support departments operated by the Submarine School.[38]

E. Use of the Escape Training Tank for Research

The use of the escape training tank as a research and testing facility began soon after it was put in service, but was formalized with the organization of the Medical Research Section of the base dispensary in 1942. The mission of the Medical Research Section at that time was to seek answers to problems in personnel selection and environmental medicine which arose out of the extensive demands placed upon the submarine force in wartime, as well as to oversee selection of men for Submarine School. Two years later, the unit was separated from the Base Medical Department as a Medical Research Department, and charged with organization and operation of schools for Pharmacist Mates, Lookout Training, Communications, and 2nd Class Divers, in addition to continuing selection and research activities. The research functions were significantly expanded in 1946, when the department was formally established as the Medical Research Laboratory, with, initially, four research "branches" for auditory problems, vision, "human engineering" and personnel selection. A physiology branch was added in 1948, and a dental research branch in 1955. In 1964, the Medical Research Laboratory was incorporated into the newly-established Naval Submarine Medical Center, but then re-established as separate "activity" in 1970. In 1974, the Medical Research Laboratory was brought under the direction of the Naval Medical Research and Development Command, headquartered in Bethesda, Maryland.[39]

The utility of the escape training tank in the Navy's medical research programs is suggested by construction of the Medical Research Laboratory's "annex" in 1949. The large number of individuals passing through the escape training course generated a valuable body of data for researchers constantly seeking new information on physiological and behavioral phenomena attending human beings in a pressurized environment. A key topic of study was the causes and circumstances surrounding casualties (fatal and otherwise) arising from pressure and tank training. For example, inquiries focused on the relationship between casualty rates and the various escape methods employed, e.g., comparison of escapes with the Momsen lung and escapes using the buoyant ascent method, or the incidence of air embolism associated with buoyant ascent and use of the Steinke hood.[40] Data on casualties were also employed to identify physiological traits which, even if an ascent were properly performed, could cause "involuntary" trapping of air inside the lungs.[41] Hazards attending the work of the instructors (divers and medical officers) were also examined, for example the problem of nitrogen build-up after several hours' working with students in the tank. Due to the limited depth at which instructors worked, there was no real danger from nitrogen narcosis as a result of performing training procedures. However, the accumulation of nitrogen presented a significant hazard in an instructor who had to institute recompression therapy on a trainee. Investigation of this problem led to changes in procedures employed by medical officers during escape training and to new information for those who might be called upon to operate a recompression chamber in such circumstances.[42]

Studies such as these relied to a great extent on data supplied "involuntarily" by those undergoing tank training. For studies involving testing or experimentation, however, the Medical Research Laboratory relied upon volunteers (often qualified divers and medical officers) to perform various data-generating activities.[43] The training tank was thus used in the initial development and testing of a wide range of apparatus, including the Steinke hood, deep dive jackets and life vests.[44] It was also used for breathholding experiments and studies to determine the composition of gas in the lungs and changes in that composition in the course of ascent from various depths.[45] Under Captain George Bond, the technique of saturation diving was developed in the 1960's utilizing the hyperbaric (recompression) chambers associated with the tank.[46] Results of these and the numerous other investigations of the Medical Research Laboratory were widely disseminated, both through Naval and other military publications and through civilian professional journals; the Medical Research library at the New London Naval Submarine Base contains an extensive collection of these publications. The escape training facility also performed important public service in the "civilian" sphere. The three-lock hyperbaric chamber was used to aid victims of diving accidents, often flown into the Submarine Base by helicopter. The tank also served as a training facility for divers of the Connecticut State Police.[47]

* * *

When the Submarine Escape Training tank was built, submarines were in a relatively early stage of development. They operated in relatively shallow waters and often close to shore. Particularly since WWII, however, shipbuilding technology and the development of nuclear power have enabled submarines to operate for longer periods at depths so great that successful escape is effectively precluded. By the mid-20th century, there was the opinion in some quarters that individual escape training was an anachronism. However, the course continued to be strongly defended by those in the Navy who believed that the psychological reinforcement and self-confidence generated by successful completion of ascents justified retention of both the course and the tank. In perhaps the last effort to obtain appropriations to repair and maintain the escape training tank, this point of view was eloquently advanced. The intent of the escape training course was to provide a "realistic...experience which tests the mental, physical and psychological responses...under simulated conditions...a highly effective training exercise that develops individual pride and confidence as well as knowledge of proper escape procedures. The screening of an individual's reaction to this training is an important element in determining that individual's adaptability to submarine duty."[48]

ENDNOTES

1 Drawings B070-20, 21, 23-31, general title Submarine Escape Training Tank, dated 2 July 1929, U.S. Department of the Navy, Bureau of Yards and Docks.

2 Drawings 4935-A, B, C, E, J, L, M, Q, general title Submarine Escape Training Tank, dated 1929-39, Petroleum Iron Works of Ohio, Sharon, Pennsylvania.

3 Drawing 18750, Navy Yard, Portsmouth, NH. Submarine Escape Training Tank, Access and Lock Openings, 24 April 1929; Drawing 18752, Navy Yard, Portsmouth, NH, Submarine Escape Training Tank, Escape Lock Door Closing Device, 5 July 1929.

4 Drawing 42785, H.H. Robertson Co., Blake Palm Elevator Corp., U.S. Navy Department. Elevator for Submarine Escape Training Tank, 24 August 1932.

5 Drawing 42785, 24 August 1932.

6 Drawing B070-19, Repairs to Training Tank: Plan, Cupola Flooring, Plumbing and Piping. 7 May 1953; B070-20, Repairs to Training Tank: Steelwork, Cupola Windows and Compressor Air Intake, 7 May 1953; B070-49, Installation of Recompression Chamber in Cupola, 16 July 1956.

7 Drawing B070-94, Alterations and Repairs to Escape Training Tank, Building 70: Floodlights and Air Lock Blisters, Padeyes, Spill Tank and Miscellaneous Details, 27 April 1959.

8 Drawing B070-77, Repairs to Training Tank: Elevator Lock Passageway and Cupola, 27 March 1961.

9 "Fire at Escape Training Tank," Dolphin, 26 April 1968, pp. 6-7.

10 Contract N62472-72-C-3347 To Construct 6 Cast in Place Concrete Caissons Approximately 60 Feet Long and Reinforced Grade Beams Cantilevering under Existing Spread Footing, 1972; Drawing B070-155, Repair of Escape Training Tank, Building 70: General Plan, Details, Insulating Panels, 24 January 1977.

11 Drawing B070-30, Submarine Escape Training Tank: Equipment House, 2 July 1929.

12 Drawing B070-53, Addition to Building 70, 3 May 1957.

13 Drawing 4412 U.S. Submarine Base New London, Connecticut and Pearl Harbor, T.H. Bureau of Yards and Docks. Blake Palm Elevator Corp., Washington, D.C., 14 July 1932; Drawing B070-8, Equipment House Addition, Submarine Escape Training Tank: Floor Plans, Elevations and Sections.

14 Drawing B070-7, Addition on East Side, Training Tank Equipment House, Building No. 70: Plans, Elevations, Sections and Details, 13 March 1936.

15 Drawing B070-8, Equipment House Addition, Submarine Escape Training Tank: Floor Plans, Elevations, Details [1937]

16 Drawing B070-12, Underwater Welding Building, 14 November 1944.

17 Drawing B070-13, Laboratory Addition to Building 70: Plans, Elevations, Sections and Details, 3 October 1949; Drawing B070-14, Laboratory Addition to Building 70: High Pressure Air Piping -- System Layout, 4 January 1950.

18 Drawing B070-55, Classroom Addition to Building 70: Plans, Sections, Details, 2 June 1958.

19 Drawing B070-90, Alterations and Repairs to Escape Training Tank: Plans, Elevations and Sections, 27 April 1959.

20 Naval Submarine Base New London, Groton, Connecticut, Centennial, 1868-1968. (Groton: Naval Submarine Base New London, 1968).

21 Naval Submarine Base New London, Groton, Connecticut, Centennial, 1868-1968; Gary R. Morrison and David J. Bishop, Submarine History Highlights 1900-1983 (Groton: Submarine Force Library and Museum, Naval Submarine Base New London, 1983), pp. 5, 7.

22 Morrison and Bishop, Submarine History Highlights, p. 7.

23 U.S. Department of the Navy, Northern Division, Naval Facilities Engineering Command, Final Master Plan, Naval Submarine Base New London, (1982), p. D-18.

24 U.S. Department of the Navy, Final Master Plan, p. D-18; "Submariners: They are Among the Most Highly Trained Men in the Fleet," (U.S. Government Printing Office, 1945), p. 1; Naval Submarine Base New London, Groton, Connecticut, Unofficial Directory and Guide (San Diego: Military Publishers, 1977), p. 12.

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26 Howard Moses, "Casualties in Individual Submarine Escape," U.S. Naval Submarine Medical Center Report No. 438 (24 October 1964) p. 6; Charles I. Hunsuck, "Submarine Base New London Escape Training Tank," (ms. 1987), p. 2; Harry J. Alvis, "Manual of Free Escape from Submarines," Medical Research Laboratory Report No. 184, IX, No. 1 (1952).

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28 Hunsuck, "Submarine Base" p. 3.

29 Moses, "Casualties," 6.

30 Interview with MMCM/SSDV John Simlich (Ret.), 30 October 1987.

31 "Submariners," p. 6.

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33 "Submariners," p. 5.

34 Interview with BMC/DV M.R. Noyes and EMCM/DV B.C.Tuck, 28 and 29 October 1987.

35 "Submariners," p. 5.

36 "Submariners," p. 5; Noyes-Tuck Interviews.

37 Noyes/Tuck Interviews; for information on the Escape Training Tank at Pearl Harbor, see Ray W. deYarmin, History of the Naval Submarine Base, Pearl Harbor, Hawaii, (Pearl Harbor: Pacific Submarine Museum, Naval Submarine Base Pearl Harbor, 1984).

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43 See, for example Bernard L. Ryack, Robert L. Rodensky, and Gary B. Walters, "Human Factors Evaluation of Submarine Escape: IA. Individual and Group Escape with the British Submarine Escape Immersion Suit and the Steinke Hood under Conditions of Side and Tube Egress," U.S. Naval Submarine Medical Center Report No. 624 (17 April 1970); and Bond et al., "Deep Submarine Escape".

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45 Arthur B. DeBois, George F. Bond and Karl E. Schaefer, "Alveolar Gas Exchange During Submarine Escape," Journal of Applied Physiology 18, No. 3 (May 1963), pp. 509-512; Karl E. Schaefer, Robert D. Allison, James H. Dougherty, Jr., Charles R. Carey, Roger Walker, Frank Yost and Donald Parker, "Pulmonary and Circulatory Adjustments Determining the Limits of Depths in Breathhold Diving," Science, Vol. 162 (29 November 1968), pp. 1020-1023.

46 Simlich Interview; Unofficial Directory and Guide, p. 14.

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EMCM/DV B.C. Tuck, Escape Training Department, Naval Submarine Base New London, October 28 and 29, 1987.

Drawings and Plans:

Drawings and Plans, in file for Building 70, at Engineering Section, Office of Public Works, Building 135, Naval Submarine Base New London, Groton, Ct.:

B070-6 Pile Driving Record, Building 70 Foundation, August 1943.

B070-7 Addition on East Side, Training Tank Equipment House, Building No. 70: Plans, Elevations, Sections and Details. 13 March 1936.

B070-8 Equipment House Addition, Submarine Escape Training Tank: Floor plans, elevations, details [1937].

B070-11 Alterations and Additions to Submarine Escape Training Tank, April 1943.

B070-12 Underwater Welding Building, 14 November 1944.

B070-13 Laboratory Addition to Building 70. Plans, elevations, sections and details. 3 October 1949.

B070-14 Laboratory Addition to Building 70. High Pressure Air Piping - System Layout. 4 January 1950.

B070-19 Repairs to Training Tank: Plan, Cupola Flooring, Plumbing and Piping. 7 May 1953.

B070-20 Repairs to Training Tank: Steelwork, Cupola Windows and Compressor Air Intake. 7 May 1953.

B070-20 Submarine Escape Training Tank, Foundation Plan. Bureau of Yards and Docks #107725. 2 July 1929.

B070-21 Submarine Escape Training Tank: Loft: Plans, Elevations and Details. Bureau of Yards and Docks # 107722. 2 July 1929.

B070-23 Submarine Escape Training Tank: General Plan of Tank. Bureau of Yards and Docks #107721. 2 July 1929.

B070-24 Submarine Escape Training Tank: Steel Framing for Loft. Bureau of Yards and Docks #107723, 2 July 1929.

B070-25 Submarine Escape Training Tank, Details of Platforms and Stairs. Bureau of Yards and Docks # 107724. 2 July 1929.

B070-26 Submarine Escape Training Tank: Details of Air Locks. Bureau of Yards and Docks #107726. 2 July 1929.

B070-27 Submarine Escape Training Tank, Details of Submarine Section. Bureau of Yards and Docks #107727. 2 July 1929.

B070-28 Submarine Escape Training Tank, Piping for Submarine Section. Bureau of Yards and Docks #107728, 26 August 1929.

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B070-30 Submarine Escape Training Tank. Equipment House. Bureau of Yards and Docks #107730, 2 July 1929.

B070-31 Submarine Escape Training Tank. Equipment House and Piping, Plans and Elevations. Bureau of Yards and Docks #107731. 2 July 1929.

B070-41 HPT Crane with Special H 2 L Hoist for Diving Bell. Chisholm Moore Hoist Corp. Drawn May 8, 1930. Traced from shop drawing 16 March 1950.

B070-48 Installation of Recompression Chamber in Equipment Room. 16 July 1956.

B070-49 Installation of Recompression Chamber in Cupola. 16 July 1956.

B070-52 Air Lock and Floodlight Blisters. 14 March 1957.

B070-53 Addition to Building 70. 3 May 1957.

B070-55 Classroom Addition to Building 70. Plans, Sections, Details. 2 June 1958.

B070-77 Repairs to Training Tank: Elevator Lock Passageway and Cupola. 27 March 1961.

B070-90 Alterations and Repairs to Escape Training Tank: Plans, Elevations and Sections. 27 April 1959.

B070-94: Alterations and Repairs to Escape Training Tank, Building 70: Floodlights and Air Lock Blisters, Padeyes, Spill Tank and Miscellaneous Details. 27 April 1959.

B070-155: Repair of Escape Training Tank, Building 70: General Plan, Details: Insulating Panels. 24 January 1977.

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4412 U.S. Submarine Base, New London, Connecticut and Pearl Harbor, T.H. Bureau of Yards and Docks. Blake-Palm Elevator Corp., Washington, D.C. 14 July 1932.

4935-A [untitled] Petroleum Iron Works Co. of Ohio, Sharon, Pennsylvania, 14 November 1929.

4935-B Submarine Escape Training Tank: Shell Development. Petroleum Iron Works Co. of Ohio, Sharon, Pennsylvania. 20 November 1929.

4935-C Submarine Escape Training Tank, Air Locks. Petroleum Iron Works Co. of Ohio, Sharon, Pennsylvania. 30 November 1929.

4935-E Submarine Escape Training Tank: Submarine Section and Trunk Details. Petroleum Iron Works of Ohio, Sharon, Pennsylvania, 2 December 1929.

4935-J Submarine Escape Training Tank: Miscellaneous Details. Petroleum Iron Works of Ohio, Sharon, Pennsylvania, 21 December 1929.

4935-L Submarine Escape Training Tank: Lock Platforms. Petroleum Iron Works of Ohio, Sharon, Pennsylvania, 11 December 1929, revised 17 January 1930.

4935-M Submarine Escape Training Tank: Detail of Brackets and Straight Stairway. Petroleum Iron Works of Ohio, Sharon, Pennsylvania, 23 December 1929.

4935-Q Submarine Escape Training Tank, Intermediate Circular Stairway Outside Stringer. Petroleum Iron Works of Ohio, Sharon, Pennsylvania, 3 January 1930.

18750 Submarine Escape Training Tank: Access and Lock Openings. Navy Yard, Portsmouth, New Hampshire, 24 April 1929.

18782 Submarine Escape Training Tank: Escape Lock Door Closing Device. Navy Yard, Portsmouth, New Hampshire, 5 July 1929.

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ADDENDUM TO
U.S. NAVAL SUBMARINE BASE, NEW LONDON
SUBMARINE ESCAPE TRAINING TANK
(U.S. Naval Submarine Base, Building 70)
Albacore and Darter Roads
Groton
New London County
Connecticut

HAER NO. CT-37-A

HAER
CONN
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MEASURED DRAWINGS

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